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Preparation of fabrication drawings for the 330 and 60°C capsules has been completed, and fabrication of parts for both capsules is nearing completion. Fabrication drawings for the 400 and 200°C capsules will be completed in 1988. Operation of the 330 and 60° capsules is scheduled to begin in February 1988, and the other two (400 and 200°C) in October 1989.

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for the first wall. Most of the available swelling data have been derived from neutron-irradiation experiments in which helium generation rates are very low (fast breeder reactors) or very high (mixed spectrum reactors). Recently a spectrally tailored experiment was concluded in the Oak Ridge Research Reactor in which the helium generation rate and damage rate were maintained at values typical of a fusion reactor operating at ~1 MW/m^2. It was found that the swelling behavior of a titanium-modified stainless steel (PCA) in both the cold-worked and solution-annealed conditions differed significantly from the behavior observed in earlier experiments in which the He/dpa ratio was either ~0.5 or ~50. The results suggest that there is a strong dependence of micro-structural evolution on the He/dpa ratio. The data are shown to be consistent with earlier theoretical predictions of swelling behavior that is a non-monotonic function of the He/dpa ratio. Finally, both the present data set and a larger collection of low-temperature swelling data are discussed in the context of near-term machines.

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and $a_0 \simeq 1.0621$ nm. Occasionally, Ti-V phosphides and sulfides [approximate $Ti_{0.5}V_{0.25}S_{0.25}$) were found in the matrix. Some of the particles. especially those containing titanium, may also contain oxygen.

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7. SOLID BREEDING MATERIALS 271

7.1 Beatrix-I Irradiation Experiment (Pacific Northwest Laboratory) 272

A tritium solid breeder irradiation experiment was designed and fabricated to reach a goal exposure of 600 full power days in the fast neutron flux of the EBR-II reactor in order to obtain swelling, tritium retention, and stability data. Lithium ceramic pellets, spheres and single crystals from Europe, Japen and the USA are contained within 19 closed capsules. Burn-up levels from 10 to 30 × 10^{20} captureslcc will be obtained during this irradiation at "isothermal" temperatures on I cm diameter pellets from approximately 500 to 900°C. Larger diameter pellets (1.6 to 2.3 cm) will produce large temperature gradients and centerline temperatures of over 1200°C. Characterization of these materials provided an assessment of current fabrication capabilities which exist for these materials.

7.2 Solid Breeder Materials Fabrication and Mechanical Properties (Argonne National Laboratory) 277

Samples of lithium orthosilicate were fabricated for mechanical properties tests. Ceranic-grade powder was synthesized from stoichiometric mixtures of lithium carbonate and amorphous silica. Samples were pressed from the powder and sintered in air at temperatures between 950 and 1100°C. Compression tests were conducted at constant cross-head speed in a furnace filled with argon. Temperatures ranged from 750 to 1000°C and strain rates were between 10^{-6} and 10^{-4} s^{-1}. A steady-state stress was obtained as a function of strain rate at each of three temperatures. The stress exponent was found to range fron a value of −6.5 at 850°C to −3.3 at 950°C. Two manuscripts were prepared for the Proceedings of the Anerican Ceramic Society Special Symposium on "Fabrication and Properties of Lithium Ceramics." Abstracts have been prepared for the 90th Annual Meeting of the Anerican Ceramic Society, Nuclear Division, to be held in Cincinnati on May 1-5, 1988.

7.3 Adsorption, Oissolution, and Desorption Characteristics of the $LiAlO_2$-H_2O System (Argonne National Laboratory) 280

Isotherms at 673 and 773 K are presented for surface adsorption of $H_2O(g)$ and for solubility of OH^- in $LiAlO_2$ as a function of $H_2O(g)$ partial pressure. The Freundlich adsorption isotherms for 673 and 773 K, respectively, are:

$$\log(\theta) = (-1.590 \pm 0.691) + (0.497 \pm 0.064) \log(p_{H_2O})$$

and

$$\log(\theta) = (-1.112 \pm 0.061) + (0.497 \pm 0.052) \log(p_{H_2O})$$

where θ is the fraction of surface covered, and p_{H_2O} is the partial pressure $H_2O(g)$ in Pascals. Hydroxide dissolution is exothermic. Depending on conditions, $LiAl_5O_8$ can be a second phase or a solute to give isotherms with slopes of 0.5 or 0.4, respectively. The hydroxide solubility isotherms for 673 and 773 K, repectively, are:

$$\log(x_{OH}) = (-4.667 \pm 0.096) + (0.399 \pm 0.088) \log(p_{H_2O})$$

and

$$\log(x_{OH}) = (-4.899 \pm 0.079) + (0.499 \pm 0.063) \log(p_{H_2O})$$

where x_{OH} is the mole fraction OH^-. The rate of $H_2O(g)$ evolution from $LiAlO_2$ showed the kinetics of the process to be second order in hydroxide with an activation energy of 14.7 ± 1.9 kcal (61.5 ± 7.9 kJ), a value less than that reported for $H_2O(g)$ evolution from Li_2O or from LiOH.

7.4 Modeling of Tritium Transport in Ceramic Breeder Materials (Argonne National Laboratory) . . . 287

A computer model to predict tritium release from a ceramic breeder was developed which considers diffusion and desorption as the rate controlling mechanisms. This model performed much better then a pure diffusion model when predicting the tritium release under pure helium purge gas for Li_2SiO_3 samples from the LISA tritium release experiment. Work is now in progress to develop a more sophisticated model which will also include transport in the gas phase. Plans have also been made to investigate the effects of processes which currently are regarded as secondary in nature. These include grain boundary diffusion, trapping, etc., in order to determine their importance in developing an overall model for tritium transport and release.

8. CERAMICS 291

8.1 Neutron Irradiation Testing of Ceramic-to-Metal Seals (Hittman Materials and Medical Components, Inc., and Los Alamos National Laboratory) 292

Butt-type ceramic-to-metal seals made from (1) niobium bonded to alumina, alon, spinel, or an alumina/silicon nitride ceramic and (2) MACOR bonded to titanium were irradiated to a dose of 4×10^{23} n/m² at room temperature. The neutron source was the beam stop area of the Los Alamos Meson Physics Facility (LAMPF). Post-irradiation testing showed that hermeticity of all but the MACOR/Ti samples was retained, even after application of 6.9×10^6 Pa (1000 psi) of hydraulic pressure. Pressurization to failure showed that all seals were capable of withstanding much higher pressures without structural failure. All ceramic-to-niobium seals appear qualified for use near the first wall of the Compact Ignition Torus (CIT) for the full lifetime of that machine while MACOR/Ti seals should be usable for lower fluences, or the full fluence where leak tightness is not required.

8.2 Damage to Macor Glass-Ceramic From High-Dose 14 MeV Neutrons (Los Alamos National Laboratory) 294

Eight samples of MACOR machinable glass-ceramic were irradiated at room temperature to fluences between 4 and 10×10^{22} 14 MeV n/m² at RTNS-II. Post-irradiation measurements showed that electrical resistivity was little changed, but that swelling was significant. The latter results are interpreted in terms of differential swelling between the glassy and crystalline phases, implying a possible loss of strength in this dose range. These findings raise a question as to whether MACOR can retain its structural properties at neutron doses characteristic of lifetime exposure at the first wall of the Compact Ignition Torus. Further work on these samples, in progress, will help to answer that question.

8.3 Improved Computation of Dielectric Constants Measured by In-Waveguide Techniques (Lor Alamos National Laboratory) 297

Brief details are presented for the derivation of a formula for calculating k from the frequency difference $\Delta f_n = f_{n+1} - f_n$ measured via the channel spectrum ["raw" data) for the transmission loss of a rectangular parallelepiped inserted within waveguide. Comparison is made in terms of the previously used formula adapted from "free-space" theory. Implications for fusion ceramics for "rf" windows are presented.

8.4 Model for Defect Aggregation and Swelling in Neutron-Irradiated Spinel (Los Alamos National Laboratory) 299

Samples of single-crystal spinel ($MgAl_2O_4$) were irradiated to neutron fluences up to 8×10^{22} n/m² [E ≥ 0.1 MeV) at ≈50°C in the Omega West Reactor. All the irradiated samples showed continued swelling out of reactor during storage at smbient room temperature. A model based on interstitial clustering has been developed that describes this post-irradiation swelling of spinel.

9. SUPERCONDUCTING MAGNET MATERIALS 305

No contributions received this reporting period